DOCUMENT RESUME

ED 362 543 TM 020 570

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TITLE The Influence of Typicality of Case Descriptions on Subjective Disease Probability Estimations.
PUB DATE Apr 93
NOTE 17p.; Paper presented at the Annual Meeting of the American Educational Research Association (Atlanta, GA, April 12-16, 1993).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Case Studies; *Clinical Diagnosis; Comparative Analysis; *Context Effect; Disease Incidence; Diseases; Foreign Countries; *Graduate Medical Students; Higher Education; Interaction; *Physicians; Probability; Symptoms (Individual Disorders)
IDENTIFIERS Expertise; *Experts; Netherlands

ABSTRACT

Previous research has shown that, unlike novice physicians' performance, diagnostic quality of expert physicians improves when contextual information (the "Enabling Conditions") about a patient is available. The present study was designed to explore these findings further by systematically varying the typicality of enabling conditions and consequences (signs, symptoms, and complaints) of a case, and determining the effect of this manipulation on subjective disease probability estimations. Subjects were 25 sixth-year (resident) students and 30 experienced family physicians in the Netherlands. A significant interaction was found between expertise level and typicality of enabling conditions in cases with prototypical consequences, but not in cases with atypical consequences. The implications of these results are discussed in terms of the illness-script theory. Two figures and one table present study data. (Contains 20 references.) (Author/SLD)

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The Influence of Typicality of Case Descriptions on Subjective Disease Probability Estimations

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Abstract

Previous research has shown that, unlike novice physicians' performance, diagnostic quality of expert physicians improves when contextual information (the "Enabling Conditions") about a patient is available. The present study was designed to further explore these findings by systematically varying the typicality of Enabling Conditions and Consequences (signs, symptoms and complaints) of a case and determining the effect of this manipulation on subjective disease probability estimations. A significant interaction was found between expertise level and typicality of Enabling Conditions in cases with prototypical Consequences, but not in cases with atypical Consequences. The implications of these results are discussed in terms of the illness-script theory.

INTRODUCTION

A medical diagnosis is often the result of a long-lasting, complex process that starts with a patient asking a physician for an appointment or a visit and ends, in some exceptional cases, with a pathologist presenting his conclusions to the hospital board. Somewhere in this process the final diagnosis must have been taken into consideration for the first time. Since pathologist is not a very common occupation it may be assumed that, in most cases, diagnosis is established in an earlier part of the process. Indeed, as Elstein, Shulman, and Sprafka (1978) have shown, physicians tend to form diagnostic hypotheses from the very first moment they see a patient. And, at least in the case of expert physicians, this small set of preliminary diagnostic hypotheses (usually less than four items) will in many cases contain the proper diagnosis. All subsequent investigations and examinations are aimed at confirming one hypothesis in this set at the exclusion of the others.

Obviously, diagnostic hypotheses that are generated in an early stage of the patient encounter can not be a consequence of peering into the patient's body, nor of ordering a decisive laboratory test. They can only be based on the information that is available in that early stage of the clinical process: the patient's background, the complaint, and (usually no more than a few) symptoms. The very fact that experienced physicians apparently arrive at quite accurate diagnoses on basis of this scarce information has led to a shift in attention from efforts to educate medical students to become good medical problem solvers and recommendations to gather as much information as possible before venturing a diagnosis, towards research into the way medical knowledge is acquired, structured and tuned to practical use. For it is not the way problems are tackled, nor the thoroughness of the investigation, nor the use of problem solving strategies, but the ability to activate the pertinent knowledge as a consequence of situational demands, which distinguishes experienced from inexperienced physicians (e.g., Barrows, Norman, Neufeld & Feightner, 1982; Elstein et al., 1978).

In cognitive science, knowledge representation and knowledge structures can be described at several levels of analysis and by several theories or models, e.g. purely symbolic (Newell & Simon, 1972), connectionistic (e.g., Hinton, McClelland & Rumelhart, 1986), procedurally oriented (e.g., Anderson, 1983) or with mental models (this latter expression being used in several, sometimes quite different senses, as for example in Gentner & Stevens, 1983, and Johnson-Laird, 1983). The better part of the research based on these theories or models deals with either very low-level tasks as letter or word recognition, or with problems in relatively well-defined domains as physics, mathematics or deductive reasoning. In contrast, an approach that draws heavily on highly structured real-world knowledge is the "script theory" developed by Schank and Abelson (1977). Scripts are defined as *standard event sequences*, and an important feature of scripts is that

they enable subjects to relate separate, syntactically unrelated statements or pieces of information. For example, these two individual sentences:
1) Yesterday we went to a restaurant
2) The waiter served a nice meal
can be related and comprehended almost without any effort by applying a "restaurant script". In fact, "scripts" constitute a specific subset of "frames" (Minsky, 1975) and "schemas" (Bartlett, 1932). The core idea of scripts as well as of frames and schemas is that they provide connectivity between separate events or phenomena that can be interrelated by real-world, often social knowledge (as opposed to items that are connected by formal or syntactical rules, as is the case in mathematics or logic). According to Schank and Abelson (1977), scripts are interconnected wholes, structures that consist of "slots" (=variables) and in which certain constraints regarding the values these slots might assume are specified. Scripts can be *activated* by hearing or mentioning the script title (called the "script header"), script actions or specific slots (e.g., "restaurant", "waiter", "menu") and *instantiated* by providing specific values to be filled in the slots (e.g., "the waiter who served us yesterday", "nice meal"). Often, slots will be filled by default (e.g., that the customers were sitting at a table when the meal was served); most slots allow for a certain variability (e.g., the waiter might be a man or a woman).

In 1984, Feltovich and Barrows introduced the notion of an "illness script". Though they used the word "script" in a somewhat different sense as either Schank and Abelson (1977) or the present authors (presently, we will elaborate on this topic), some features of the script approach make it a particularly appealing instrument to describe the structure of medical knowledge. First, in understanding medical as well as common real-world situations, an extensive mass of knowledge is involved. Second, script headers (in medicine: the names of diseases) or slots (e.g., patient characteristics, symptoms) can be used to activate specific parts of that knowledge as interconnected wholes. Third, the slots of an illness script can be filled with specific values, e.g., regarding contextual factors, patient characteristics, symptoms, signs or complaints. Like in the original Schank and Abelson scripts, a certain amount of variability is possible, as the same disease might manifest itself differently in individual patients (i.e., the actual instantiations of an illness script might differ between patients). Consequently, an illness script is conceptualized as an integrated knowledge structure that can be activated as a whole in a practical medical situation, and that can be instantiated according to the available patient information.

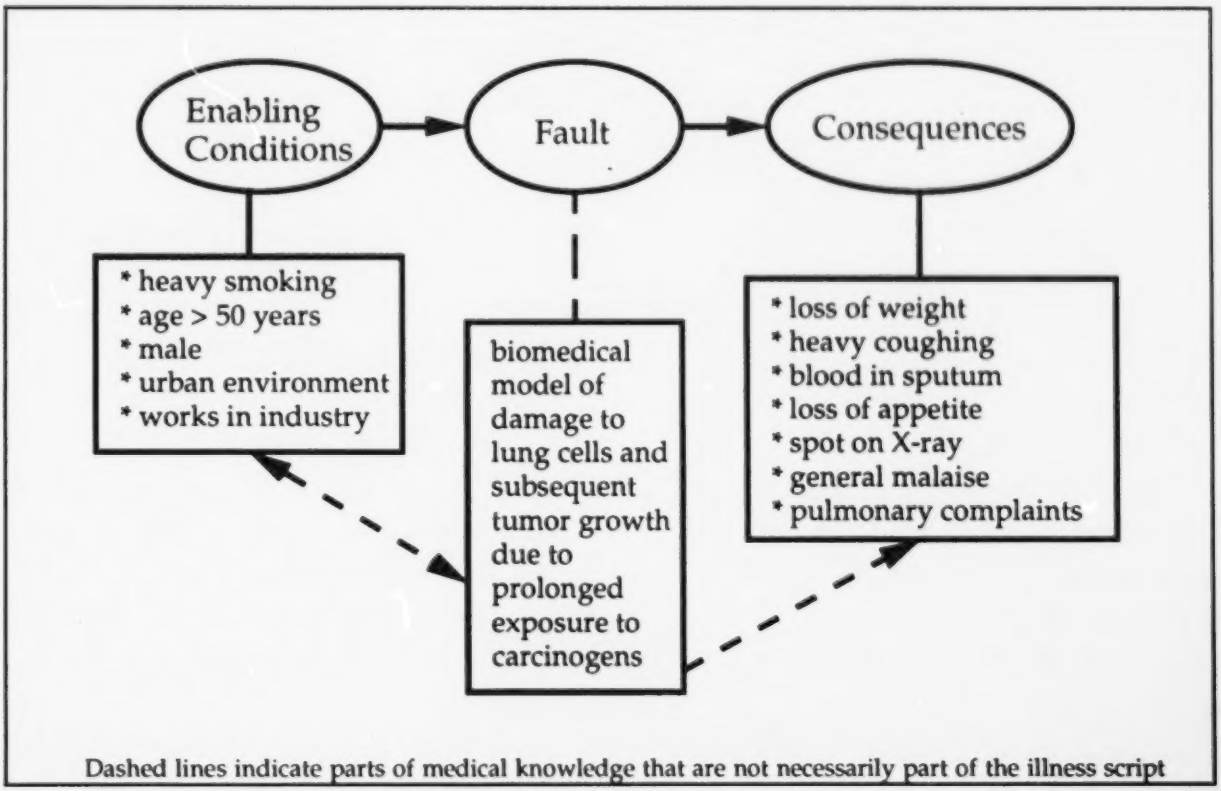
An illness script contains three important components (Feltovich & Barrows, 1984):
1) The "Enabling Conditions": knowledge about the factors that influence the probability that someone gets afflicted by a particular disease, like the patient's age, gender, medical history, current medication, occupation, social circumstances, housing situation and risk behavior;
2) The "Fault": knowledge about the nature of the biomedical malfunction in the human

body;

3) The "Consequences": knowledge about the specific signs, symptoms and complaints resulting from the Fault.

As illness scripts are integrated knowledge structures, these different components are interconnected. Figure 1 shows an example of an illness script. Research by several investigators has revealed some characteristics of illness scripts: (1) though intermediates (e.g., advanced students) may already possess all the relevant knowledge, probably several years of additional practical experience are necessary to develop full-fledged illness scripts (Custers, Boshuizen, & Schmidt, 1992; Hobus, Schmidt, Boshuizen, & Patel, 1987); (2) especially the appropriate use of Enabling Conditions in a diagnostic situation requires a relatively advanced stage of medical expertise (Hobus, Hofstra, Boshuizen, & Schmidt, 1988; Hobus, Boshuizen, & Schmidt, 1990); (3) the overt role of biomedical (i.e., Fault-related) knowledge decreases when more mature illness scripts emerge (Boshuizen & Schmidt, 1990, 1992; Custers et al., 1992; Patel, Evans, & Groen, 1989). Expert physicians mainly rely on Enabling Conditions and Consequences and use biomedical knowledge merely to justify or explain certain (unexpected) findings with respect to the current diagnosis.

Figure 1. Example of an illness script (disease: "lung cancer")


Enabling Conditions
Fault
Consequences
* heavy smoking
* age > 50 years
* male
* urban environment
* works in industry
biomedical model of damage to lung cells and subsequent tumor growth due to prolonged exposure to carcinogens
* loss of weight
* heavy coughing
* blood in sputum
* loss of appetite
* spot on X-ray
* general malaise
* pulmonary complaints
Dashed lines indicate parts of medical knowledge that are not necessarily part of the illness script

As a consequence of these research findings, we opt for a somewhat modified form of the Feltovich and Barrows' illness scripts. Whereas in their original approach an illness script is constructed for each individual patient on account of medical basic science knowledge, in our view illness scripts can be directly retrieved from memory (i.e., activated) and instantiated for a particular patient. Especially the usual patient characteristics, signs, and symptoms of a disease will be more or less automatically activated when the appropriate illness script is retrieved; it will not be necessary to construct an extensive biomedical explanation for each of them.

Though the Hobus et al. (1987) study provided important new information regarding the differences between experienced and inexperienced physicians, much is still unknown about the role of Enabling Conditions and Consequences in medical diagnosis and in the application of medical knowledge. Diseases share an important property with all natural categories: their instances (in case of diseases: individual patients) can very to a certain extent in appearance, though still being examplars of that particular category. As indicated above, illness scripts can account for these variations. Thus, within a group of patients with a specific disease, Enabling Conditions as well as Consequences may show a great variability. However, many patients will show Enabling Conditions and Consequences that are quite typical for their illness. In terms of categorization theory, they will bear a close resemblance to the (imaginary) prototypical patient for that disease. For an experienced physician, they will constitute the routine cases: the appropriate illness scripts will be quickly activated upon seeing such prototypical patients. Nevertheless, there will also be patients who diverge from this prototypical patient with respect to age, sex, medical history, main complaint, additional complaints, symptoms or signs. For example, they might be younger than expected for a particular disease, or an important complaint might be absent, or they might show symptoms that are shared by only a minority of the patients with that particular disease. These patients will be more or less atypical for their disease.

The illness script theory states that with increasing experience, illness scripts will be tuned (cf. Rumelhart & Norman, 1978) toward natural occuring variations in the way diseases manifest themselves. This might be accomplished by the addition of extra slots to the script, or by a change in the range of values that can be filled in specific slots at the time of instantiation. However, in case of atypical patients, there will often be some room for doubt as to whether the instantiated script indeed fits the actual patient. This will be especially true if both Enabling Conditions and Consequences in a particular patient are atypical for the disease in question.

Thus, experienced physicians will be more inclined to accept a diagnostic hypothesis regarding a specific case if the Enabling Conditions and Consequences of the patient described in that case fit their illness script for the hypothesized disease, than if one or

both of these components are at variance with it. Or, in other words, if a case is presented in which a patient with prototypical Enabling Conditions and prototypical Consequences with respect to a particular disease is described, an experienced physician will assign a higher probability to that disease than if one or both of these components are of a more atypical character. Students or inexperienced physicians, on the other hand, will be mainly sensitive to typicality of Consequences of a disease, as their illness scripts are relatively well developed with respect to this component (Custers et al., 1992). Prototypicality or atypicality of Enabling Conditions will not exert a large influence on their probability ratings: in activating their illness scripts, students and less experienced physicians will chiefly rely on the complaints, signs and symptoms of a case. If these Consequences are typical for the disease at hand, students will tend to assign a high probability to that disease; if they are not, their probability estimation will be considerably lower.

We tested this hypothesis by constructing patient case descriptions in which typicality of Enabling Conditions and Consequences was systematically varied. By presenting these case variants to sixth-years medical students and experienced physicians, the relative influence of prototypicality of Enabling Conditions and Consequences on diagnostic decisions for two different levels of medical expertise can be established. We did not require subjects actually to diagnose cases, but asked them to estimate the probability that the patient described in the case was suffering from a specific disease. It might be expected that the more a case description fits the illness script a subject has for that particular disease, the higher the estimated probability will be. Thus, if experienced physicians rely more on Enabling Conditions than inexperienced physicians, the former subjects will assign higher probabilities to patients with prototypical Enabling Conditions than the latter subjects, regardless of the nature of the Consequences.

METHOD

Subjects

Subjects were 25 sixth-year students[1] and 30 experienced family physicians. The sixth-year students had either completed their residency or were about to complete it; so they had on the average 2 years experience in a clinical setting. The family physicians had on average 11.75 years experience as family physicians, ranging from 1 year to 25 years.

Material

Based on 20 different diseases, computerized case descriptions were constructed. Each

case consisted of a number of statements. The statements provided information about the setting (e.g., consultation hour, emergency telephone call, house call), the patient's background, his or her complaint, and some symptoms.

For 16 of the 20 diseases, four different case variants were constructed. One variant described a patient with prototypical Enabling Conditions and prototypical complaints and symptoms. Case descriptions of this type will be referred to as PP cases. In a second variant a patient with atypical Enabling Conditions, but prototypical complaints and symptoms was described. Cases of this type will be called AP cases. An example of such a variant might be a young non-smoker, living in a rural environment, showing complaints and symptoms that highly suggest lung cancer. A third variant described a patient with prototypical Enabling Conditions but atypical Consequences. These are the PA cases. An example of such a case (if based on the disease "lung cancer") might be an elderly heavy smoker, with unexplained weight loss, but no pulmonary complaints. Finally, in a fourth variant Enabling Conditions as well as Consequences were atypical. Cases of this type will be referred to as AA cases. Thus, couched in terms of an illness script, the first "P" or "A" of the case type refers to the Enabling Conditions, while the second "P" or "A" refers to the Consequences. It should be emphasized that, for a particular disease, the information about patient background and setting described in the PP and PA case variants was exactly the same; and this also holds for the atypical Enabling Conditions information in the AP and AA case variants, for the prototypical Consequences in the PP and AP variants, and for the atypical Consequences in the PA and AA variants. This means, for example, that the description of the patient with prototypical Enabling Condtions for pre-infarct syndrome (e.g., male, age over 50, advanced stage of atherosclerosis, high blood pressure) is in both variants the same, whether the complaints and symptoms are prototypical or atypical. Appendix A gives an example of a case with its four variants, along with some comments. A consequence of this setup is that the effects of typicality of Enabling Conditions and Consequences on the disease probability estimations are experimentally separable.

As only one variant of each case could be presented to every subject, four different sequences of cases had to be constructed, with each of the four variants of any case appearing in only one of the sequences. Each sequence contained four variants of the PP type, four of the AP type, four of the PA type and four of the AA type. Thus, every subject processed four cases of each type. The cases were randomly arranged within the sequence.

For the remaining four diseases, so-called "filler cases" or "distractor cases" (DI-cases) were constructed. These were cases in which a patient was described with a completely different disease than the name of the case indicated. The four DI-cases were inserted at random positions in each of the four sequences. This type of cases was added to contrast atypical (AA) cases with obvious noncases (DI-cases), in order to investigate whether the AA-cases still had some plausibility with regard to the diseases they were based on.

Procedure

Subjects were tested individually. Cases were presented on a Macintosh computer screen. The experimenter started each case presentation by saying: "Read this case and decide whether this is a patient suffering from X", with X being the disease on which the case description was based[2]. After the case presentation was completed, subjects had to estimate the probability (expressed as a percentage between 0 and 100) that the patient described in the case was suffering from the disease previously mentioned by the experimenter. Subsequently, the next case was presented.

Analysis

Average percentage estimations for each subject over the four cases of the same type (PP, AP, PA, AA, and DI) were computed. This procedure yielded five average percentage measures per subject: one for each case type. These percentage measures were analyzed by means of a 2 (levels of expertise) by 5 (case type) analysis of variance, with expertise level as between subjects factor and case type as within subjects factor. However, our main interests concerned not the overall analysis of variance, but separate contrasts between different case types. First, we contrasted PP cases with AA cases, in order to check whether the prototypical-atypical manipulation was generally effective. Similarly, we contrasted AA type cases with DI type cases, to check whether AA cases still had some plausibility, compared to noncases. Finally, since our main hypothesis was that experienced physicians would be more influenced by Enabling Conditions than sixth-year students, and we did not have any preconceived theories about the relative impact of Enabling Conditions and Consequences on probability estimations, two separate contrasts were computed: one in which we compared PP and AP case types (i.e., to investigate the influence of Enabling Conditions in cases with prototypical complaints and symptoms), and one in which we compared PA and AA case types (i.e., to investigate the influence of Enabling Conditions in cases with atypical complaints and symptoms).

RESULTS AND DISCUSSION

Table I shows the results. Analysis of variance revealed no significant main effect of expertise and no significant interaction. However, the main effect of case type was significant ($F(4,212)=227.26$, $p < .0001$). Thus, manipulating two aspects of case typicality clearly had an effect on probability estimations. Subjects generally assigned a high disease probability to the patients described in the PP case variants (76.5% average over both levels of expertise), while for the AA case variants this estimation was much lower (41.0% over both levels of expertise). The AP and PA

type cases fell somewhere in between, with probability estimations of 61.3% and 55.7%, respectively. These latter figures indicate that Enabling Conditions and Consequences each have their own contribution in determining the probability estimations. The DI case variants received a probability of 9.9% over both groups of subjects.

Two contrast were computed to check whether the case type manipulation was effective. A separate analysis of variance for PP and AA type cases revealed a significant main effect of case type ($F(1,53)=148.199$, $p < .0001$), but no significant main effect of expertise level, nor a significant interaction. Thus, AA type cases were assigned a significantly lower probability estimation than PP type cases, and this effect was of about the same magnitude for both expertise levels. Similarly, an analysis of variance for AA and DI type cases also revealed a significant main effect of case type ($F(1,53)=147.43$, $p<.0001$), but no significant main effect of level of expertise and no significant interaction. So, AA type cases received a significantly higher probability estimation than DI type cases, which indicates that the former case variants are by no means implausible; indeed, percentage estimations of about 40% for both expertise levels suggest that even case descriptions with atypical Enabling Conditions and atypical Consequences are, at least to a certain extent, conceived as instances of a particular disease.

Further results are depicted in Figure 2. For the PP and AP case variants, analysis of variance revealed a significant main effect of case type on probability estimation ($F(1,53)=55.398$, $p < .0001$). PP case types generally receive a higher probability estimation than AP case types. No significant main effect of level of expertise was found. However, Figure 2 (left hand panel) shows a significant interaction between

Table I
Average probability estimations (expressed as percentages) as a function of expertise and case type

	case type					
level of expertise	PP	AP	PA	AA	DI	mean
6th year students (N=25)	72.68	62.77	53.73	41.31	12.49	48.60
family physicians (N=30)	79.67	60.12	57.34	40.77	7.74	49.13
mean	76.49	61.32	55.70	41.01	9.90	48.89

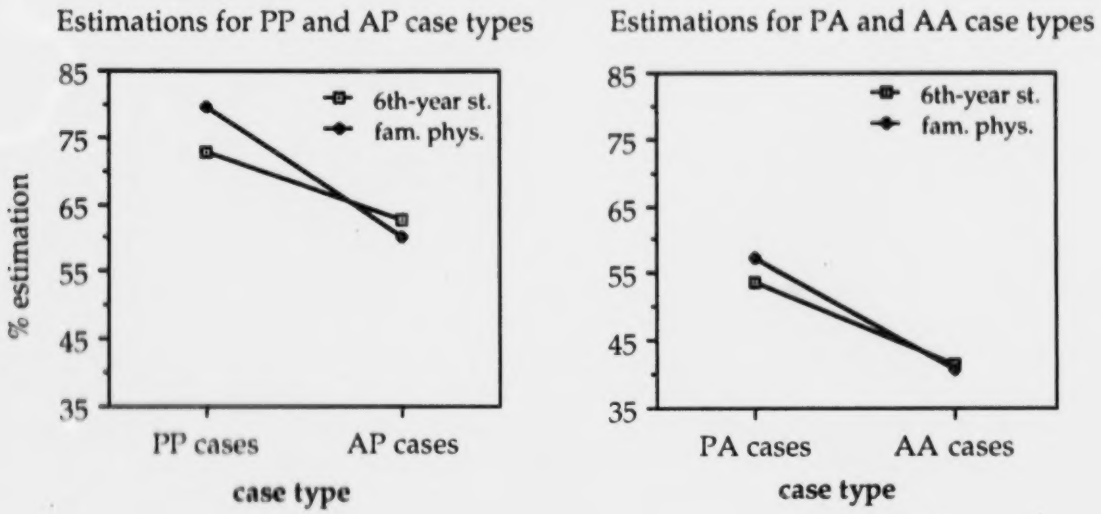
level of expertise and case type ($F(1,53)=5.548$, $p < .05$). Apparently, family physicians are more sensitive in their probability estimations to prototypicality of Enabling Conditions than sixth-year students. These results are in line with the illness script theory.

Figure 2 (right hand panel) shows the results for the PA and AA case variants. The picture is somewhat different here. Again, a main effect of case type was found ($F(1,53)=40.118$, $p < .0001$). A patient with atypical Consequences, but with prototypical Enabling Conditions receives a higher probability estimation than a patient for whom both Consequences and Enabling Conditions are atypical. Just like in the previous analysis of variance, no significant main effect of level of expertise was found. However, in the present analysis, neither a significant interaction was found. This finding suggests that, when they have to estimate the probability that patients with atypical Consequences have a specific disease, experienced physicians are no more sensitive to prototypicality of Enabling Conditions than sixth-year students.

These results indicate that development of illness scripts beyond the level of sixth-year students is confined principally to cases of patients with prototypical complaints and symptoms. Only in these cases experienced family physicians are more apt than sixth-years students to take Enabling Conditions into consideration, at least as far as diagnostic certainty is concerned. Perhaps experienced physicians have refined their illness scripts in such a way that they are especially sensitive to combinations of prototypical Enabling Conditions and prototypical Consequences. On the other hand, the present results might also be a consequence of experience with different populations. The majority of patients consulting a family physician will be prototypical with respect to their disease for Enabling Conditions as well as for Consequences. Sixth-year students, on the other hand, who have recently walked the wards, might have been exposed to typical hospital populations, i.e., to all sorts of patients with specific diseases, among which many with atypical Enabling Conditions and/or atypical Consequences.

Further research is needed to investigate whether the present results also hold for diagnostic situations. If it is indeed the case that experienced physicians outperform less experienced physicians mainly on prototypical patients with prototypical complaints and symptoms, then an important recommendation for medical education might be derived from it: provide students with ample opportunity to see prototypical patients, and do not confront them in an early stage with too many atypical cases.

Figure 2. Probability estimations as a function of case type and expertise



REFERENCES

Anderson, J. R. (1983). *The architecture of cognition.* Cambridge, MA: Harvard University Press.

Barrows, H. S., Norman, G. R., Neufeld, V. R., & Feightner, J. W. (1982). The clinical reasoning of randomly selected physicians in general medical practice. *Clinical & Investigative Medicine, 5,* 49-55

Bartlett, F. C. (1932).*Remembering.* Cambridge, MA: Cambridge University Press.

Boshuizen, H. P. A. & Schmidt, H. G. (1990). *Biomedical knowledge and clinical expertise.* Paper presented at the Annual Meeting of the American Educational Research Association, Boston, MA, April 16-20, 1990.

Boshuizen, H. P. A. & Schmidt, H. G. (1992). On the role of biomedical knowledge in clinical reasoning by experts, intermediates and novices. *Cognitive Science, 16,* 153-184

Custers, E. J. F. M., Boshuizen, H. P. A., & Schmidt, H. G. (1992). *The relationship between medical expertise and the development of illness-scripts.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA, April 20-24, 1992.

Elstein, A. S., Shulman, L. S., & Sprafka, S. A. (1978). *Medical problem solving: an analysis of clinical reasoning.* Cambridge, MA: Harvard University Press.

Feltovich, P. J. & Barrows, H. S. (1984). Issues of generality in medical problem solving. In: H. G. Schmidt & M. L. De Volder (Eds.), *Tutorials in problem-based learning: a new direction in teaching the health professions.* Assen: Van Gorcum.

Gentner, D. & Stevens, A. L. (Eds.), (1983). *Mental models.* Hillsdale, New Jersey: Erlbaum.

Hinton, G. E., McClelland, J. L., & Rumelhart, D. E. (1986). *Distributed representations.* In: D. E. Rumelhart & J. L. McClelland, (Eds.), *Parallel distributed processing..* Cambridge, MA: The MIT Press.

Hobus, P. P. M., Schmidt, H. G., Boshuizen, H. P. A., & Patel, V. L. (1987). Contextual factors in the activation of first diagnostic hypotheses: Expert-novice differences. *Medical Education, 21,* 471-476.

Hobus, P. P. M., Hofstra, M. L., Boshuizen, H. P. A., & Schmidt, H. G. (1988). De context van de klacht als diagnosticum [The context of the complaint as a diagnostic tool]. *Huisarts en Wetenschap, 31,* 261-263.

Hobus, P. P. M., Boshuizen, H. P. A., & Schmidt, H. G. (1990). *Expert-novice differences in the role of contextual factors in early medical diagnosis.* Paper presented at the Annual Meeting of the American Educational Research Association, Boston, MA, April 16-20, 1990.

Johnson-Laird, P. (1983). *Mental models.* Cambridge, MA: Harvard University Press.

Minsky, M. A. (1975) A framework for representing knowledge. In: Winston, P. H. (Ed.), *The psychology of computer vision.* New York: McGraw Hill

Newell, A. & Simon, H. A. (1972). *Human problem solving.* Englewood Cliffs, New Jersey: Prentice Hall.

Patel, V. L., Evans, D. A. & Groen, G. J. (1989). Biomedical knowledge and clinical reasoning. In: Evans, D. A. & Patel, V. L. *Cognitive science in medicine. Biomedical modeling.* Cambridge, MA: The MIT Press.

Rumelhart, D. E. & Norman, D. A. (1978). Accretion, tuning and restructuring: Three modes of learning. In: R. Klatzky & J. W. Cotton, (Eds.), *Semantic factors in cognition.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Schank, R. C. & Abelson, R. (1977). *Scripts, plans, goals and understanding.* Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Schmidt, H. G., Norman, G. R., & Boshuizen, H. P. A. (1990). A cognitive perspective on medical expertise: theory and implications. *Academic Medicine, 65,* 611-621.

Appendix A

Example of a case description with four variants
Case 6: kidney stones (colic)
The number preceding each text phrase refer to the number of the screen image in which that particular phrase was presented

PP-variant:

1. Man, age 47, married, three children
2. Occupation: store-keeper
3. Medical history: bronchitis at age 30
4. Had his leg broken six years ago, as a consequence of a car accident
5. Four years ago: received medication for kidney stones
6. Some of his relatives are known to have coronary disease and diabetes mellitus
7. His wife rings up, asks the physician for an urgent house call:
8. Just like a few years ago, her husband is rolling across the room because of the pain. He is also vomiting almost continuously
9. When the physician arrives, the pain has just subsided. The patient is sitting on the sofa and recovering a bit
10. At the moment, the patient doesn't look very ill
11. He complains about having had a convulsive abdominal pain abreast of the umbilicus, at the left side
12. The pain is radiating to his groins
13. The pain emerges very suddenly, and then gradually subsides. During an attack he almost can't stand it
14. Earlier that day he had already seen some blood in his urine, but had had no pain at that time
15. Is this a patient with a kidney stone colic? (yes/no)
16. Please estimate the probability that this person has a kidney stone colic in a percentage (range between 0%-100%)

Comment: the prototypical patient with kidney stone colic is a male, aged 35 to 55 years (statement 1), who has had this kind of complaint before (statement 5). As the clinical picture often is rather impressive, it is not unusual that relatives panic (statement 7). Typically, the pain is of a convulsive nature, about half-way down the abdomen, and one-sided (left or right, statement 11). Radiation to the groins is also very prototypical (statement 12). The same holds for the pain-free intervals, during which the patient appears normal (statement 9, 10, 13). During an attack, people are literally running or cringing (statement 8, 13). Blood in the urine may also occur, before or after an attack (statement 14). The statements 2, 3, 4 and 6 are added to complete the case-description (occupation is usually mentioned, as are some rather irrelevant medical history items with regard to the present condition)

AP-variant:

1. Woman, 32 years, married, two children
2. Occupation: works at the clerical staff of a large school
3. Medical history: bronchitis at age 20
4. Had her leg broken six years ago, as a consequence of a car accident

5. Has been taking oral contraception for nine years, interrupted for pregnancies
6. Some of her relatives are known to have coronary disease and diabetes mellitus
7. Her husband rings up, asks the physician for an urgent house call:
8. He is afraid that his wife is dying: she is rolling through the room because of the pain. She is also vomiting almost continuously
9. When the physician arrives, the pain has just subsided. The patient is sitting on the sofa and recovering a bit
10. At the moment, the patient doesn't look very ill
11. She complains about having had a convulsive abdominal pain abreast of the umbilicus, at the left side
12. The pain is radiating to her groins
13. The pain emerges very suddenly, and then gradually subsides. During an attack she almost can't stand it
14. Earlier that day she had already seen some blood in her urine, but had had no pain at the time
15. Is this a patient with a kidney stone colic? (yes/no)
16. Please estimate the probability that this person has a kidney stone colic in a percentage (range between 0%-100%)

Comment: Kidney stones are not often found in young women. In addition, nothing in her medical history points to the possible existence of this ailment. The symptoms (the same as in the previous description) are very prototypical, though.

PA-variant:

1. Man, age 47, married, three children
2. Occupation: store-keeper
3. Medical history: bronchitis at age 30
4. Had his leg broken six years ago, as a consequence of a car accident
5. Four years ago: received medication for kidney stones
6. Some of his relatives are known to have coronary disease and diabetes mellitus
7. The patient appears at consulting hour with the complaint:
8. Since the other day, occasionally a sharp, stabbing pain in the abdomen, abreast of the navel, at the right side
9. The pain is radiating to his groins
10. He had already felt for a few days a somewhat nagging sensation in this part of his abdomen
11. And it is still nagging, now, in between the stabs
12. Upon inquiry, the patient admits having felt an urge to micturate more often than usual, the last few days, but the amount of urine each time was small
13. He says he doesn't feel very well
14. And reports having measured 37.8 degrees (Centigrade) temperature
15. Is this a patient with a kidney stone colic? (yes/no)
16. Please estimate the probability that this person has a kidney stone colic in a percentage (range between 0%-100%)

Comment: this pattern of symptoms and complaints is possibly, but not very likely caused by kidney stones.

AA-variant:

1. Woman, 32 years, married, two children
2. Occupation: works at the clerical staff of a large school
3. Medical history: bronchitis at age 20
4. Had her leg broken six years ago, as a consequence of a car accident
5. Has been taking oral contraception for nine years, interrupted for pregnancies
6. Some of her relatives are known to have coronary disease and diabetes mellitus
7. The patient appears at consulting hour with the complaint:
8. Since the other day, occasionally a sharp, stabbing pain in the abdomen, abreast of the navel, at the right side
9. The pain is radiating to her groins
10. She had already felt for a few days a somewhat nagging sensation in this part of her abdomen
11. And it is still nagging, now, in between the stabs
12. Upon inquiry, the patient admits having felt an urge to micturate more often than usual, the last few days, but the amount of urine each time was small
13. She says she doesn't feel very well
14. And reports having measured 37.8 degrees (Centigrade) temperature
15. Is this a patient with a kidney stone colic? (yes/no)
16. Please estimate the probability that this person has a kidney stone colic in a percentage (range between 0%-100%)

Comment: Upon seeing this patient and hearing her complaints, the physician will probably not immediately think of kidney stones. However, the possibility of this disease is surely not ruled out.

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[1] In the Netherlands, medical education consists of a six year curriculum

[2] Except for the DI type cases, which were actually based on a completely different diasease than the one announced by the experimenter at the beginning of the case presentation.